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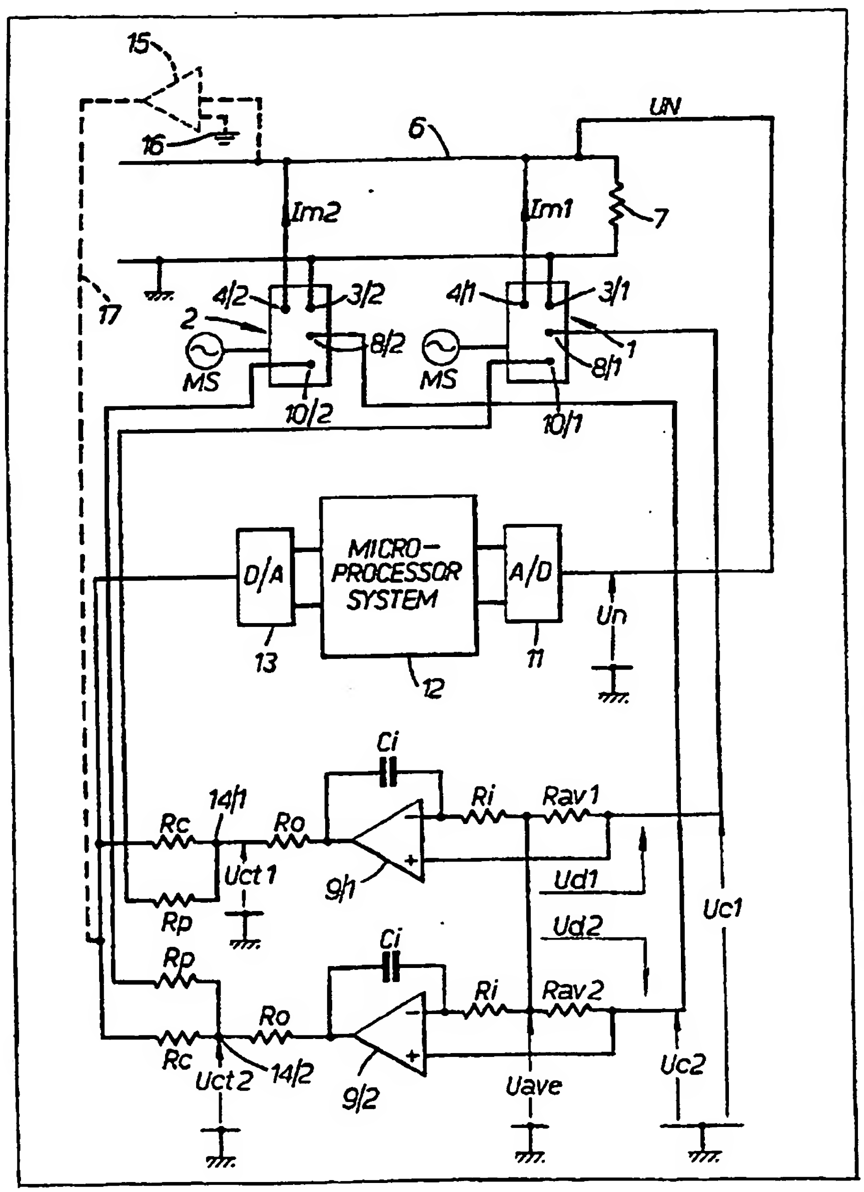
(54) Power supplies with parallel supply modules

(57) A power supply system includes at least two power supply modules 1, 2 connectable in parallel to a load 7. The system also includes means 9/1, 9/2 responsive to the magnitude of the currents supplied by each module to generate signals to control each of the modules so as to share the demand for current between the modules in a predetermined manner. The control signals adjust the respective output voltages of the modules, and the overall output voltage UN is stabilised either by a feedback amplifier 15 or by a microprocessor 12 which may also provide protection and sequencing control.



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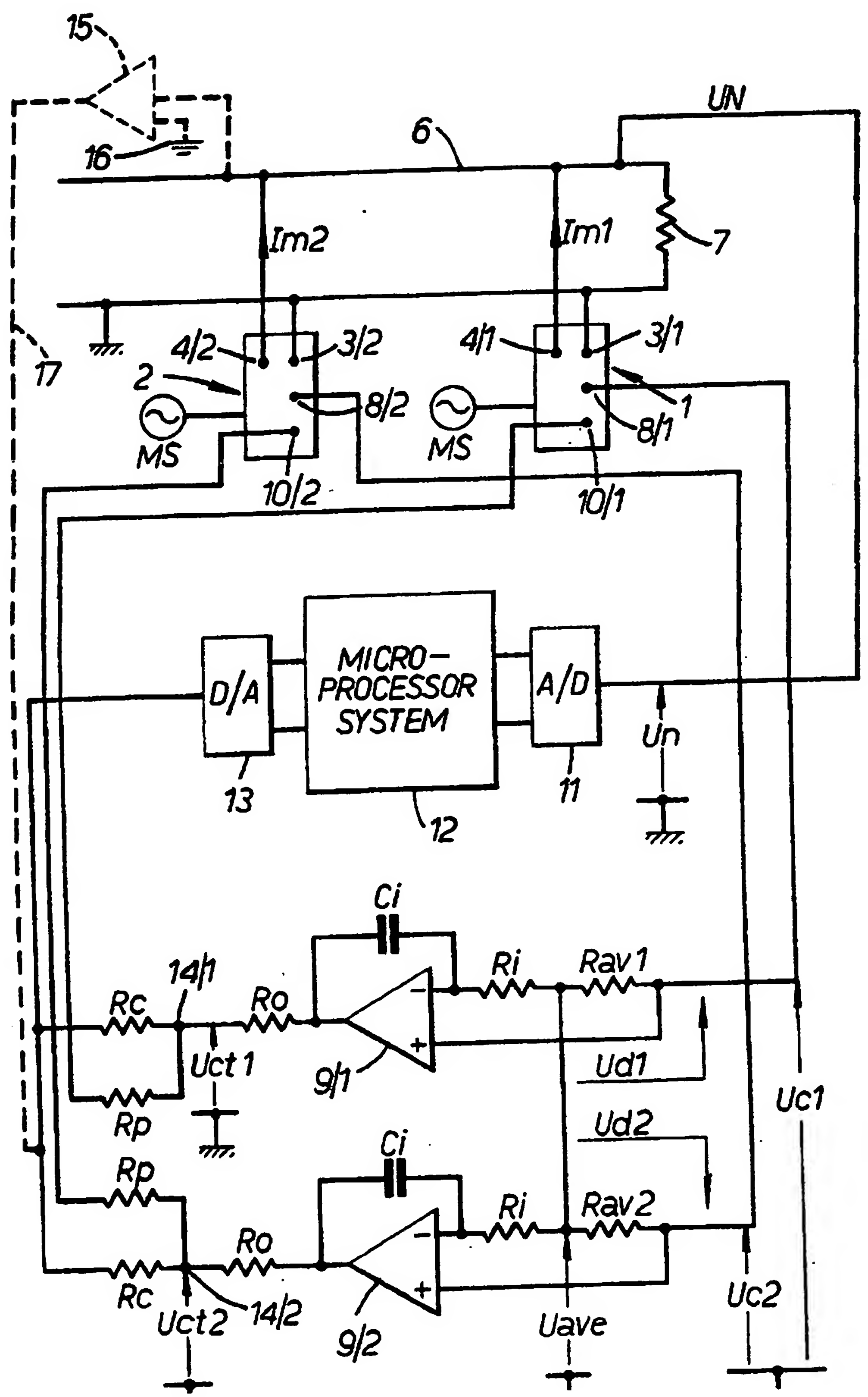
15
16
17
UN
6
Im2
Im1
7
4/2
3/2
4/1
3/1
2
1
8/2
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MS
MS
10/2
10/1
MICRO-
PROCESSOR
SYSTEM
D/A
A/D
13
12
11
Un
Ci
Ri
Rav1
14/1
Rc
Ro
Uct1
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Rp
Ud1
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Uc1
Ci
Rp
Ri
Rav2
Ro
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Uct2
14/2
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Uave
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SPECIFICATION
Improvements in or relating to power supplies

This invention relates to power supplies for electronic equipment and in particular to power supplies consisting of a number of power supply modules operating in parallel.

Electronic equipment such as computer systems usually needs to be supplied with power at a controlled stable voltage. In order to meet the high current demand, a number of power supply modules may be connected in parallel. Each module incorporates an output voltage control circuit and due to the very high d.c. gain of this control circuit there is a tendency for one of the modules to supply maximum current whereas other modules each supply less than maximum current. The module operating at maximum current is subjected to greater stress than the other modules and hence is more liable to breakdown than would be the case if all the modules share the current demand equally and thereby all the modules operate at less than maximum current.

Attempting to adjust the modules to share the current demand equally requires excessive time when commissioning new equipment and if any changes occur during use of the equipment such as replacement of a module, the laborious adjustment procedure would need to be repeated.

According to the invention a power supply including a number of power supply modules connected to deliver current to a common load includes means responsive to the magnitude of the currents supplied by each module to generate control signals to control each of the modules in such a manner as to share the demand for current between the modules in a predetermined manner.

An embodiment of the invention will now be described with reference to the drawing which shows a load sharing control circuit for a power supply consisting of two power supply modules.

Referring to the drawing, two power supply modules 1, 2 have output terminals 3/1, 3/2, and 4/1, 4/2 connected in parallel to power bus lines 5, 6 to which a load 7 is connected. The modules 1, 2 are each powered from a mains electricity supply, MS. The modules 1, 2 each include voltage stabilisation circuitry arranged to control the output voltage from the modules to a value of Un, and the modules respectively supply currents Im1 and Im2. The modules 1, 2 each incorporate current monitoring circuits responsive to the currents Im1, Im2 respectiv ly to generate at monitor output terminals 8/1, 8/2 voltage signals Uc1, Uc2 having magnitudes representing the magnitudes of the currents Im1, Im2. The signals Uc1, Uc2 are applied to one input of comparators 9/1, 9/2 respectively. The signals Uc1, Uc2 are also appli d to resistors Rav1 and Rav2 which hav a common interconnection wh reby the common ends of the resistors Rav1, Rav2 have a pot ntial Uave equal to the average of the value applied via integrating networks RlCl to the second inputs of the comparators.

The outputs of the comparators 9/1, 9/2 are connected to resistor networks Ro, Rc, Rp. The difference voltages Ud1 Ud2, developed across the resistors Rav1, Rav2 are integrated to generate control voltages Uct1, Uct2 at the junctions 14/1, 14/2 of the resistors networks. These control voltages Uct1, Uct2 are fed via resistors Rp to remote control inputs 10/1, 10/2 of the modules 1, 2. The voltage stabilising circuits in the modules are responsive to the control voltages Uct1, Uct2 such that the stabilised output voltages are varied to cause the current Im1 Im2 to tend toward equal values so that the monitor signals Uc1, Uc2 tend toward the value Uave and hence to a state in which the difference voltages Ud1, Ud2 are equal to zero. However although this results in equal sharing of the load current, the output voltage Un may not be stabilised at the desired value.

In order to maintain the output voltage at a desired stable value Un, the common power line 6 is connected to the input of analogue to digital converter 11. The digital output of the A/D converter 11 is applied as an input to a microprocessor system 12 arranged to drive a digital to analogue converter 13. The output of the converter 13 is applied via the registors Rc to the common points 14/1, 14/2 of both of the networks Ro, Rc, Rp and hence via the resistors Rp to the remote control inputs of both of the modules 1, 2. The microprocessor system 12 is arranged to produce an output signal from the D/A converter 13 such that the output voltage Un on the line 6 is maintained at a stable desired value. Since the output signal from the converter 13 acts into the same loop as the current control, balancing of the currents between the modules is unaffected. The characteristic of the output voltage control is determined by the microprogram controlling the microprocessor system and this may be designed to meet any special requirements. The microprocessor system may be utilised in addition to supervise extra facilities such as monitoring of overvolt and undervolt conditions and sequencing different modules. Although the embodiment is described as incorporating a microprocessor system, if only voltage stabilisation is required without these other facilities, the line 6 may be connected to one input of a comparator 15 shown as a dashed line 16 with a voltage reference connected to the other input. The output of the comparator is then connected by the line 17 shown dashed to the resistors Rc of all the networks.

The above described embodiment includes two power supply modules, but it will be appreciated that larger numbers of modules may be used to meet the current demand. Each module has its current monitor output connected to a separate comparator 9 and resistor Rav, all th resist rs Rav having a c mmon interconnection so as to generate an average signal Uave representing the

module.

In some instances, it may be desired to meet a current demand by unequal sharing between modules for example when modules designed for different current demands are utilized. The control of such unequal sharing may be accomplished by feeding the current monitor outputs Uc1, Uc2 via potentiometer networks to the resistors Rav so that if for example one module is intended to supply n times the current of the other module, the signal Uc for that one module would be divided by n so that to the comparator 9 it would appear that that module was supplying the same current as the other module and a ratio of n:1 would be maintained between the currents supplied by the modules.

CLAIMS

1. A power supply system including at least two power supply modules connected to deliver current to a common load, the system including means responsive to the magnitude of the current supplied by each module to controlling each module such that the modules share the demand for current by the load in a predetermined manner.

2. A power supply system as claimed in Claim 1, wherein each said module is intended to supply the same current output as any other module included in the system.

3. A power supply system as claimed in Claim 1, wherein when it is desired to meet an overall current demand by a predetermined unequal sharing between the modules, the means responsive to the magnitude of the current supplied by the modules is adapted to control the output of individual modules according to the predetermined nature of the unequal sharing.

4. A power supply system as claimed in Claim 1, 2 or 3, and wherein each said module incorporates a voltage stablising circuit which serves to control the magnitude of the output voltage of the associated module to a predetermined value and wherein the means responsive to the output voltage includes for each such module a comparator means for comparing the instantaneous output voltage characteristic of the current output of the associated module with a second voltage representing the average of all said output voltages to produce an output from which is derived said control signal.

5. A power supply system as claimed in claim 4, wherein for each said module the output from the associated comparator is fed to an associated resistive network to develop a control voltage which provides the associated control signal, and wherein the associated voltage stabilising network is so responsive to said associated control signal that the stabilised output voltage of the associated module is varied to cause the current outputs of the modules to tend towards equal values so that the instantaneous output voltages tend towards an average voltage value whereby the second voltages tend to zero.

6. A power supply system as claimed in Claim 5, and further including means for stabilising the output voltage developed across said load terminals.

7. A power supply system as claimed in Claim 6, wherein the stabilising means is arranged to provide a further control signal which is combined with the control voltage provided for each said module.

8. A power supply system, as claimed in Claim 7, wherein the stabilising means includes analogue to digital convertor arranged to feed input to a microprocessor system which is arranged to establish a stable voltage value, and which in turn controls a digital to analogue converter whose output is applied by way of the associated resistive networks of the modules to the associated voltage stabilising networks.

9. A power supply system, constructed and arranged to operate substantially as hereinbefore described with reference to the accompanying drawing.

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